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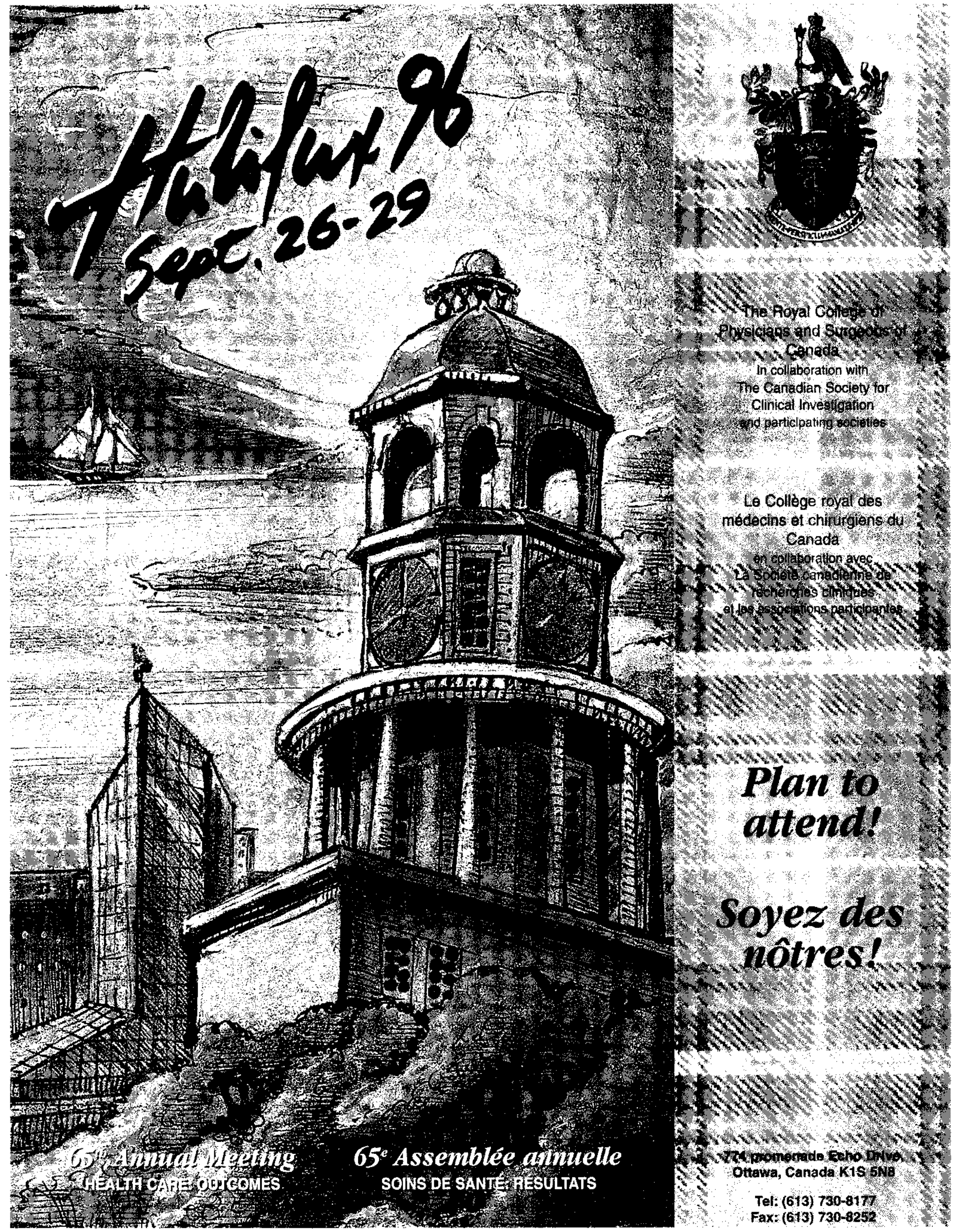

Laboratory Testing in Intensive Care: Does the Admitting Hospital Affect Costs?

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Abstract

To determine whether differences in intensive care unit (ICU) costs occur between hospitals we studied city-wide patterns and frequency of testing and interventions in 6 teaching hospital and 5 community hospital adult ICU's. Demographics, APACHE II, TISS, diagnoses, and frequency of 17 common laboratory tests were retrospectively obtained for 100 consecutive admissions to each of the units beginning September 15, 1993. Patients were classified as Medical, Surgical, or Cardiac admissions. Acquisition of a significant adverse event during the ICU stay was noted. The following groups were analyzed: teaching hospital 1 (TH1, n=300), teaching hospital 2 (TH2, n=300), and community hospitals (CH, n=500). Multiple regression analysis was done for cardiac, medical and surgical categories using laboratory cost as the dependent variable and TH1 as the reference. Data with ranges are mean ± SD.

Parameter	TH1	TH2	CH
APACHE II	16.3 ± 9.0	15.4 ± 8.1	14.7 ± 8.2
LOS (days)	3.3 ± 6.1	3.1 ± 3.8	3.7 ± 4.7
Med/Surg/Card (%)	30/ 33/ 37	24/ 36/ 40	22/ 26/ 51
Ventilator/Art line/PAC(%)	48/ 61/ 28	52/ 60/ 35	21/ 33/ 9
Lab cost/admission ($)	$276 ± 425	$370 ± 479	$226±307
Lab cost/day ($)	$ 90 ± 159	$106 ± 63	$64 ± 46

Multiple regression analysis analysis revealed that acquired diagnosis was a significant ($p<0.0001$) predictor of increased costs for all diagnostic categories, and that admission at TH2 was more costly than TH1 ($p<0.0001$). These results suggest that significant differences in laboratory testing frequency and costs exist between hospitals that cannot be explained by acuity, diagnosis, or type of patient. This could have cost saving implications if these excess tests do not improve patient care.

Introduction

In the last decade most comparative intensive care unit (ICU) performance evaluations have concentrated on survival outcomes using predictive models. Despite the expensive nature of critical care there have been few attempts to compare and characterize patterns of resource utilization and costs between intensive care units. Because of limitations in costing models used in previous studies there is little information with respect to identifying significant determinants of resource utilization across institutions.

Objective

To identify and discriminate between patient linked and institutional determinants of ICU resource consumption.

Method

Data was retrospectively obtained by study nurses from the charts of 100 consecutive admissions to each of the 11 units beginning September 1, 1992. Study nurses retrospectively determined the primary reason for ICU admission, and collected up to 5 additional admission diagnoses. Iatrogenic, nosocomial, or new disease processes developing after ICU admission were recorded as acquired diagnoses. All data was entered into a previously described ICU research and resource utilization computerized database. (Critical Care Manager, TMS Inc, Chelmsford, Ontario).

For comparisons the 11 study units were separated into three groups. One teaching hospital (TH1; n=300) operates a longstanding information based management program directed towards improving quality and efficiency of care in ICU. The other teaching hospital (TH2; n= 300) has no similar program in operation. The five community hospitals (CH; n=500) provide similar levels of care, share common administrative features, and have no ongoing extensive resource management programs.

A. Diagnostic Categories

Each admission was categorized as MEDICAL, SURGICAL, or CARDIAC. Patients admitted from recovery or operating rooms, or following trauma, burns, or upper GI bleeding were categorized as SURGICAL. CARDIAC admissions included patients with myocardial infarctions, acute rhythm disturbances, unstable angina, chest pain, congestive heart failure, and patients admitted for coronary angiography or angioplasty. MEDICAL admissions included patients with cardiogenic shock, those resuscitated from cardiopulmonary arrest, or those suffering from problems that did not fall into SURGICAL or CARDIAC categories.

B. Outcome Variables

Frequency and cumulative costs of 17 laboratory and imaging procedures were collected for each ICU admission. These investigations included biochemical tests (arterial blood gas (ABG), potassium, glucose, creatine kinase (CK), creatine kinase MB (CKMB), complete blood count (CBC), CBC with manual differential, creatinine, magnesium, prothrombin/partial thromboplastin time (PT/PTT), aspartate serum transferase (AST); microbiologic procedures (cultures of blood, sputum and urine); imaging procedures (chest radiograph and abdominal ultrasound); and electrocardiograms. This group of investigations previously accounted for over 60% of all diagnostic costs in 6000 consecutive ICU admissions at TH1. A previously described cost list derived at TH1 was updated and utilized for all units.

C. Covariates

Demographic data included age, sex, date and time of ICU admission and discharge, and ICU mortality. Worst Acute Physiology and Chronic Health Evaluation II (APACHE II) score during the first 24 hours of ICU admission, and a daily Therapeutic Intervention Scoring System (TISS) score for the first 5 days of ICU were collected.

D. Statistical Analysis

Analysis of Variance (ANOVA) was used for continuous variables and frequency data was compared using Chi square. An all subset multiple linear regression with cost as the dependent variable was performed for each category of admission (MEDICAL, SURGICAL, CARDIAC), using SAS (SAS Institute,) and Statistica (Statsoft, Tulsa, OK) with $p<0.05$ for significance. Length of stay (LOS), arterial line insertion, pulmonary artery catheter placement, and vasoactive drug use were tested for interaction with institution using dummy variables. The baseline hospital used for comparisons was TH1.

Table 1: Demographic, diagnostic category and intervention data at all three locations

Parameter	TH1	TH2	CH
Number	300	300	500
Mean APACHE II	16.3 ± 9.0	15.4 ± 8.1	14.7 ± 8.2
Mean TISS score	27.4 ± 15.0	29.8 ± 15.2	19.9 ± 9.1
Mean LOS (days)	3.3 ± 6.1	3.1 ± 3.8	3.7 ± 4.7
Age (years)	61.8 ± 16.8	64.3 ± 14.4	66.8 ± 15.2
MEDICAL (%)	89 (30%)	71 (24%)	112 (22%)
SURGICAL (%)	98 (33%)	108 (36%)	131 (26%)
CARDIAC (%)	113 (37%)	121 (40%)	257 (51%)
Ventilated (%)	48	52	21
Arterial line (%)	61	60	33
PA catheter	28	35	9

Results are mean ± SD, p assessed by ANOVA
APACHE II = Acute Physiology and Chronic Health Evaluation score
TISS = Therapeutic Intervention Scoring System; PA Catheter = pulmonary artery line
* $p < 0.03$ TH1 vs CH; + $p < 0.0001$ CH vs both TH1 and TH2; ‡ $p < 0.0001$ CH vs TH1

Table 2: Effect of category and location of admission on laboratory and imaging costs

Mean cost per admission ($)	TH1	TH2	CH
MEDICAL	355 ± 440	604 ± 768	322 ± 443
SURGICAL	364 ± 519	385 ± 308	176 ± 379
CARDIAC	113 ± 86	220 ± 297	211 ± 143
Mean cost per ICU day ($)			
MEDICAL	90 ± 56	117 ± 51	91 ± 72
SURGICAL	126 ± 63	166 ± 68	66 ± 49
CARDIAC	67 ± 39	78 ± 47	68 ± 42

p values from ANOVA
* p = 0.002 for TH2 vs TH1; p = 0.0002 for TH2 vs CH
† p = 0.01 for CH vs TH1; p 1.4= 0.001 for CH vs TH2
‡ p < 0.0001 for TH1 vs TH2 and for TH1 vs CH
§ p < 0.0001 for TH2 vs CH

Table 3: Final regression model of cost for MEDICAL admissions (n = 272; $R^2 = 0.87$)

Variable	Parameter estimate	p Value
Intercept	18.9	
Length of stay (days)	47.8	0.0001
TISS score (per point)	6.2	0.0001
Acquired diagnosis (Y/N)	215.4	0.0001
Age (per year)	-1.4	0.0385
Admit TH2 (Y/N)	-100.7	0.0127
Admit CH (Y/N)	-26.5	0.4542
LOS at TH2 (days)	66.2	0.0001
LOS at CH (days)	16.7	0.0004

LOS = length of stay; ACQ = acquired diagnosis; TISS = Therapeutic Intervention Scoring System; CH = Community hospitals; TH2 = Teaching hospital 2

Regression equation:
Cost = 18.9 + 47.8(LOS) + 6.2(TISS) + 215.4(ACQ) - 1.4(AGE) - 100.7(TH2) - 26.5(CH) + 66.2(LOS@TH2) + 16.7(LOS@CH)

Table 4: Final regression model of cost for SURGICAL admissions (n = 337; $R^2 = 0.86$)

Variable	Parameter estimate	p Value
Intercept	-139.7	
Length of stay (days)	67.0	0.0001
TISS score (per point)	4.1	0.0001
APACHE II score (per point)	5.8	0.0001
Acquired diagnosis (Y/N)	105.6	0.0018
Admit TH2 (Y/N)	23.3	0.3957
Admit CH (Y/N)	-37.3	0.1576
LOS at TH2 (days)	23.9	0.0001
LOS at CH (days)	12.5	0.0004

LOS = length of stay; ACQ = acquired diagnosis; TISS = Therapeutic Intervention Scoring System; APACHE II = Acute Physiology and Chronic Health Evaluation II score; CH = Community hospitals; TH2 = Teaching hospital 2

Regression equation:
Cost = -139.7 + 67.0(LOS) + 4.1(TISS) + 5.8(APACHE) + 105.6(ACQ) + 23.3(TH2) - 37.3(CH) + 23.9(LOS@TH2) + 12.5(LOS@CH)

Table 5: Final regression model of cost for CARDIAC admissions (n = 491; $R^2 = 0.64$)

Variable	Parameter estimate	p Value
Intercept	-37.0	
Length of stay (days)	23.1	0.0002
TISS score (per point)	6.0	0.0001
Acquired diagnosis (Y/N)	275.2	0.0001
Myocardial infarction (Y/N)	36.5	0.0014
Admit TH2 (Y/N)	-53.0	0.0127
Admit CH (Y/N)	57.1	0.0034
LOS at TH2 (days)	51.2	0.0001
LOS at CH (days)	-7.4	0.2511

LOS = length of stay; ACQ = acquired diagnosis; TISS = Therapeutic Intervention Scoring System; MI = myocardial infarction; CH = Community hospitals; TH2 = Teaching hospital 2

Regression equation:
Cost = -37.0 + 23.1(LOS) + 6.0(TISS) + 275.2(ACQ) + 36.5(MI) - 53.0(TH2) + 57.1(CH) + 51.2(LOS@TH2) - 7.4(LOS@CH)

Table 6: Acquired diagnoses at all locations

	TH1	TH2	CH
Total admissions	300	300	500
Number with acquired (%)	9 (3%)	13 (4%)	38 (8%)*
COMMON ACQUIRED DIAGNOSES			
pneumonia	2	2	10
rhythm disturbance	1	1	6
acute renal failure	0	2	4
GI bleed	0	1	3
line complication	1	3	0
cerebrovascular accident	1	1	2
ARDS	1	1	1
acute surgical procedure	1	0	2
pulmonary embolus	0	0	2
septic shock	1	1	0
myocardial infarction	0	1	1
congestive heart failure	0	1	1

Only includes diagnoses occurring in more than one patient. Some patients had more than one acquired diagnosis.

* p = 0.0064 by Chi square vs teaching hospitals (TH1 and TH2)
GI bleed includes upper and lower gastrointestinal bleeding
ARDS = Adult Respiratory Distress Syndrome

Table 7: Incidence and mean APACHE II scores of non-survivors by diagnostic category at each location

Category	TH1	TH2	CH
MEDICAL mortality (%)	22 (24.7)	17 (23.9)	29 (25.9)
APACHE II score	33.4 ± 8.7	29.5 ± 7.5	30.3 ± 9.3
SURGICAL mortality (%)	21 (21.4)	6 (5.6)	2 (1.5)
APACHE II score	26.6 ± 8.9	22.1 ± 3.9	23.0 ± 5.3
CARDIAC mortality (%)	4 (3.5)	3 (2.5)	11 (4.3)
APACHE II score	37.3 ± 12.7	26.7 ± 2.3	23.9 ± 10.8

Values with range are mean ± SD

χ^2 = 10.0; p = 0.0016 for TH1 vs TH2
= 22.4; p < 0.0001 for TH1 vs CH

Summary

1) None of the diagnosis or procedurally based subcategories for MEDICAL or SURGICAL admissions were predictive of cost.
2) Age was only a weak negative predictor of cost in the MEDICAL group and did not emerge in the final regression models for SURGICAL or CARDIAC admissions.
3) Worst APACHE II score in the first 24 hours correlated with cost in SURGICAL admissions but failed to emerge as a significant factor in the other two groups.
4) The observation that TISS scores were lower in TH1 vs TH2 despite higher mean acuity levels at TH1 (table 1) suggests that location may be an independant determinant of level of intervention.
5) The interaction of location and length of stay was an important determinant of cost in all three admission categories.
6) Acquisition of a significant diagnosis following admission was clearly predictive of increased admission costs in all three diagnostic groups.
7) Acquired diagnoses occurred more frequently at CH than at either TH1 or TH2 ($p<0.001$). This observation is difficult to explain since CH admissions had the lowest mean APACHE II score, and a comparatively low level of intervention as assessed by day 1 TISS score, including reduced incidence of mechanical ventilation and invasive monitoring.

Conclusions

Our study indicates that there are differences in the patterns of resource utilization between the intensive care units in our city. Mucb of this difference was clearly not related to patient based demographic or diagnostic characteristics. Our data further demonstrates that much of the cost difference is determined by institutionally linked factors that may relate to local conditions such as isolated development of routines for the ordering of tests and investigations and differences in the incidence of complications and other adverse events. Other factors beyond the control of ICU personnel such as availability of ward beds or operating room facilities may have a significant effect on length of stay and subsequent costs.

Finally our cost analysis demonstrates that at least in terms of utilization of tests and investigations tertiary care teaching hospital ICU's can be as or more efficient than community hospital intensive care units with application of information based management techniques.